Response to Referee Comments

Referee #2:

We sincerely appreciate your valuable feedback and constructive suggestions, which have significantly contributed to improving the quality of our manuscript. Below, we provide detailed responses to your comments and outline the corresponding revisions we have made.

1. "There is garbled text on line 156 of page six that needs to be corrected."

   We apologize for this oversight. We have carefully reviewed line 156 on page six and corrected the garbled text to ensure clarity and accuracy.

   "CNNs, or Convolutional Neural Networks, are deep learning algorithms widely employed for various image-related tasks such as image recognition, classification, and regression. They learn and extract essential features from raw images by processing them through multiple layers of filters, known as "convolutions." This multi-layer processing progressively extracts more abstract features."

2. "The conclusion needs to further highlight the innovative points."

   In response to this suggestion, we have substantially revised the conclusion to provide a more comprehensive discussion of our model's innovations. We now explicitly emphasize:

   "Conclusion:

   This study presents an innovative deep learning framework utilizing a Convolutional Neural Network (CNN) to generate a continuous subsidence surface across the study area. Unlike traditional methods that rely on discrete geodetic measurements, the proposed approach integrates multiple key driving factors—including NDVI, distance from wells, land use, water table depth, altitude, slope, SPI, TWI, and aspect—providing a more comprehensive and data-driven understanding of subsidence dynamics. The CNN model effectively addresses the limitations of PSInSAR, which, despite its reliability in detecting gradual land deformation, is restricted to persistent scatterers (PSs) and performs poorly in vegetated or low-coherence areas. By leveraging deep learning, the proposed model enables subsidence estimation even in regions where PSInSAR measurements are unavailable, addressing a critical gap in geospatial monitoring.

The superiority of the CNN-based approach was demonstrated through a comparative analysis against conventional interpolation techniques, including Kriging, IDW, and RBF. The CNN model achieved significantly lower RMSE values (3.99 mm, 8.47 mm, and 9 mm for the training, validation, and test datasets, respectively) and an R^2 score of 0.98, whereas traditional methods exhibited considerably higher RMSE values (Kriging: 61.60 mm, IDW: 66.21 mm, RBF: 61.76 mm) and negative R^2 scores, highlighting their limitations in subsidence prediction. The study also identified severe land subsidence in key areas, with rates exceeding 45 mm per year at Shahid Beheshti Airport and over 54 mm per year in the Mahyar Plain. The CNN model demonstrated an 85% improvement in prediction accuracy over traditional methods, underscoring its robustness and effectiveness, particularly in areas with sparse and irregularly distributed data.

Despite these advancements, some challenges remain. The model's performance is influenced by the availability and quality of input data, and its computational demands necessitate high-performance GPUs for efficient training. Additionally, regional variations in subsidence mechanisms may require model adaptations to ensure accuracy across diverse landscapes. Future research should focus on enhancing the model's generalizability across different geographical regions, developing real-time monitoring capabilities for early warning systems, and integrating additional datasets—such as climate variables and bedrock depth—to further refine predictive accuracy. Furthermore, exploring hybrid deep learning architectures, such as CNN-LSTM models, may enhance computational efficiency and improve temporal prediction capabilities. Addressing these aspects will further establish deep learning-based subsidence modeling as a scalable and effective tool for geospatial analysis, environmental monitoring, and urban planning."

3. "The resolution of the image is not clear enough and needs to be strengthened."

   Thank you for pointing this out. We have improved the resolution of all figures to ensure clarity and readability. The updated figures now provide higher-quality visual representations of the subsidence maps, making it easier for readers to interpret the results accurately.

We appreciate your insightful comments, which have helped us refine our manuscript. We believe that the revisions have significantly strengthened the study and hope that the updated version meets your expectations.